IN SITU BIOGEOCHEMICAL PROCESS FOR THE TREATMENT OF CHLORINATED ORGANICS AND METALS

Background

For over two decades, biotic (enhanced reductive dechlorination; ERD) and abiotic (in situ chemical reduction; ISCR) processes have been applied to degrade chlorinated volatile organic compounds (CVOCs) in situ. Recently, biogeochemical reduction (BGCR), a process which combines biological and chemical processes, has been combined with ERD and ISCR to provide an additional mechanism to more aggressively degrade CVOCs and to sequester metals.

During ERD and ISCR, highly reducing conditions are generated which are favorable to the reduction of ferric iron (Fe^{3+}) to ferrous (Fe^{2+}) and sulfate (SO_4) to sulfide (S^-). If present, the ferrous and sulfide rapidly combine to produce iron-sulfide minerals such as mackinawite (FeS), and pyrite (FeS_2). These biologically generated minerals have been demonstrated to abiotically degrade CVOCs on contact by the β elimination pathway. This pathway minimizes the generation of toxic degradation products thereby substantially reducing the clean-up time. In addition to forming reactive minerals, the sulfide will precipitate on zero valent iron (ZVI) if present. This sulfidation of ZVI has been demonstrated to substantially enhance ZVI reactivity.

Approach

Bench tests, field pilot studies and full-scale treatment have been conducted to evaluate the effectiveness two BGCR enhancing reagents (Geoform™ Extended Release and Geoform™ Soluble) for treatment of CVOCs and sequestration of toxic metals. These reagents have been applied at sites with distinct hydrogeologic and geochemical conditions, and contaminant concentrations. Innovative analytical techniques were used to confirm the generation of the formation and characterize the type of minerals formed.

Results

The bench tests demonstrated that BGCR enhancement significantly increased the reactivity of the ISCR reagent. The field tests demonstrated that the biologically mediated establishment of highly reducing conditions resulted in the reduction of the supplied sulfate to sulfide. Analysis confirmed that the sulfide combined with the supplied ferrous resulting in the rapid generation of a combination of reactive iron sulfide minerals. The combination of these technologies resulted in the rapid destruction of CVOCs and sequestration of toxic metals.

This presentation will describe the synergistic changes in geochemical conditions which occur during BGCR enhanced ERD and ISCR. The unique methods for identifying these newly formed minerals will be described, and the results of full-scale application of BGCR enhanced ERD and ISCR for treatment of CVOCs and metals will be presented.